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6 items enclosed

F04611-98-C-0003

MEMORANDUM FOR PR (Contractor/In-House Publication)

FROM: PROI (TI) (STINFO) 26 Oct 2000

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-2000-209** D. Schwartz (AFRL/PRRM), R. Bennett (Thiokol), K. Graham (ARC), T. Boggs (NAWC) , "Current Efforts to Develop Alternate Test Protocols for the Joint Technical Bulletin 'Department of Defense Ammunition and Explosives Hazard Classification Procedures' TB700-2, dated 5 January, 1998" (VuGraphs)

JANNAF PSHS **(Statement A)**
(Monterey, CA, 13-17 Nov 2000) **(Submission Deadline: 30 Oct 00)**

1. This request has been reviewed by the Foreign Disclosure Office for: a.) appropriateness of distribution statement, b.) military/national critical technology, c.) export controls or distribution restrictions, d.) appropriateness for release to a foreign nation, and e.) technical sensitivity and/or economic sensitivity.
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PHILIP A. KESSEL Date
Technical Advisor
Propulsion Science and Advanced Concepts Division

Current Efforts to Develop Alternate Test Protocols for the Joint Technical Bulletin "Department of Defense Ammunition and Explosives Hazard Classification Procedures" TB700-2, Dated 5 January, 1998.

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2000 JANNAF CS/APS/PSHS & M&SS Joint Meeting
Monterey 13-17 November 2000

Hazard Classification Background

- Recent History in Hazard Classification Procedures
  - On January 5, 1998, DoD released TB 700-2, NAVSEAINST 8020.8B, AF TO 11A-1-47 as a revision to NAVSEAINST 8020.8A dated December 1989
    - Describes test methods and criteria for defining substance and article hazards class: 1.1, 1.2, 1.3, 1.4, etc.
    - Applies to all explosives entering DoD system
    - Concerns shipping and storage of explosives only - not use
    - Rocket propellants specifically defined as explosives for this document
    - For small rockets, explosives, etc., describes UN test protocols
    - For large rockets, describes alternate tests
- Why the Changes
  - To Assure standardization with UN testing

Test Protocol Old Vs. New

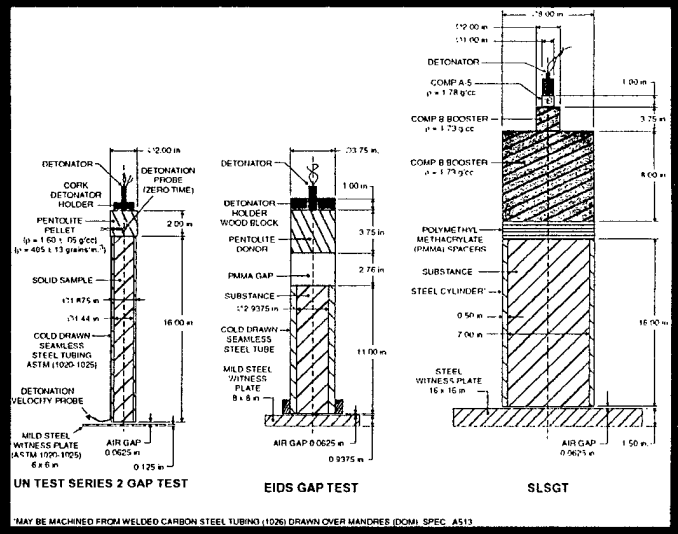
- DOT Test Series (Same as for IHC) Subscale
  - #8 Blasting cap to initiate internally
    - 0.5 g explosive
  - NOL Gap Test
    - 1.44" Diameter x 5.5" long pipe
    - 2" Diameter x 2" long pentolite booster
    - <70 Cards
    - 1/8th-Inch witness plate
    - 'Go' criteria
      - Pipe split entire length
      - Sustained detonation velocity
      - Hole in witness plate
  - Open burning
    - 2" Propellant cubes
- Standard UN Test Series 6 (full size) each tested 3 times
  - Single Package Test
    - Test substance packed as it will be shipped
    - 1st Trial: #8 blasting cap (0.5 g explosive) to initiate internally
    - 2nd, 3rd Trials: ignite internally
      - Use article's own ignition device (for rocket motors, it can be a static test
      - Class 1.1 if package explodes
  - Stacked Test
    - Test substance packed as it will be shipped
  - Bonfire Test
    - Test substance packed as it will be shipped

Historical Test Protocol for Large Rocket Motors

- In Practice, Full-scale Articles Not Tested by Either DoT or DoD
  - Hazard Classifier or field representative outlined tests required in addition to IHC requirements
  - Detonability requirements never more severe than 70-card NOL Large Scale Gap Test for determining hazard classification
  - DoT continues to rely on subscale tests and expertise of field rep.

Alternate Tests to UN Test Series 6

- Authors of TB 700-2 Recognize Impracticality of UN Test Series 6 For Large Rocket Motors
- Alternate Tests
  - All focus on propellant detonability (shock sensitivity)
  - All have varying card gaps down to zero
  - All have same 'Go' criteria
    - Sustained detonation velocity
    - Hole in witness plate
    - Pipe split entire length
    - If 'Go', is hazard division 1.1



Note on Class 1.1 Vs. 1.3

- Some Have Operated Under the Misconception that:
  - Class 1.1 = Detonable Under Some Condition
  - Class 1.3 = Not Detonable Under Any Condition
- These Have Been the Definitions of Class 1.1 and 1.3
  - Most Class 1.3 rocket propellants will be detonable if a large enough sample is provided with a sufficient shock input
  - The question and ambiguity have rather been: 'Where do we draw the line?
    - Historically, that line has been 70 cards in the NOL LSGT

Problems With Alternate Tests

- Don't Address Same Properties as UN Test Series 6
  - Almost certain to get different results from nominal and alternate tests
- Shock to Propellant (>280 kbar) is Much Greater than Any Storage/Transportation Hazard
  - Truck head-on collisions (<0.3 kbar)
  - Fragment slap from explosion (<1 kbar)
- Many Propellants Demonstrated to Pass IM Requirements Will Fail Alternate Tests
  - Motor will not explode in combat conditions, but defined as explosive hazard (class 1.1) for normal peacetime transportation and storage
- Much More Severe Than Tests Required for IHC

Implications of Changes

- Many Propellants, Motors With Interim Hazards Classification of Class 1.3 Will Have Final Hazards Classification of Class 1.1
  - IHC still only requires 'no go' at 70 cards in NOL LSGT
- Most Current and Future IHPRPT Solid Propellants Would Not Pass 8-inch Test
- Many Class 1.3 Motors Now in Production Would Be Classified As Class 1.1
  - Mk104 boost certainly
  - Mk104 sustain likely
  - All minimum signature propellants

Past Actions Taken

- Government Laboratory & Industry Concerns and Positions Presented at JANNAF PSHS/SHC & PDCS Meetings and Workshops
  - All parties agreed on shortcomings of TB 700-2 protocol
  - Overall consensus position not reached
  - At 1999 PSHS meeting, JANNAF SHC panel chairman collected inputs including proposed alternate test protocols for submission to DDESB
  - At 1999 Joint Propulsion Meeting, JANNAF SHC panel chairman proposed issues and alternate test protocols be presented to DDESB and tri-service hazard classifiers at JANNAF PDCS workshop in May

Status of Current Efforts to Revise TB 700-2

- January 2000, Individuals From Thiokol, AFRL, ARC and NAWC Formed an Industry & Government Laboratory Team To:
  - Educate community members about TB 700-2
  - Unite community to develop alternate test protocols
- Efforts Focused on the Two Main Areas of Concern:
  - Full-scale requirement under UN Test Series 6 protocol cost prohibitive for large rocket motors
  - Zero card requirement for the alternate gap tests represents an unreasonable shock stimulus

Meeting & Workshop Efforts

- May 2000, JANNAF PDCS Meeting
  - Paper on "Comments and Position Regarding TB 700-2" identified ramifications to solid rocket community and potential alternate test protocols
  - Workshop sought consensus on the recommended configuration of a shock sensitivity test in terms of:
    - Sample dimensions
    - Input charge dimensions (diameter & length)
    - Stand-off distance (attenuation

Meeting & Workshop Efforts (Cont)

- PDCS Workshop Consensus:
  - All of the shock sensitivity tests should be attenuated down to 70 Kbars as a minimum and possibly much lower for the SLSGT
  - SLSGT sample length needs to be doubled to allow either the propagation of a stable detonation reaction or the decaying of the reaction to sonic velocities
- Jul 2000, DDESB explosives safety seminar
  - Updated paper reiterated ramifications to community and sought their consensus and participation to develop potential alternate test protocols

Meeting & Workshop Efforts (Cont)

- Workshop sought to address the questions of:
  - Can subscale analog cookoff specimens be designed, tested and modeled to adequately mimic full-scale articles?
  - Can data be provided giving confidence that motors containing propellants in the range of 0 to 69 cards (NOL) will not detonate in external fire cook-offs?
- Workshop also addressed how to best match the full-scale articles in terms of:
  - Case burst pressure
  - Case and insulation materials
  - Thermal gradients during cookoff
  - Analog dimensions
  - Grain geometry
- Claude Merrill presented a proposal for a sub-scale hazard classification program using external fire tests

Meeting & Workshop Efforts (Cont)

- DDESB Workshop Consensus:
  - Efforts to develop, test and model a sub-scale analog motor vital to the solid rocket community
  - Starting point should be the extensive database the Navy generated on the 203.20-millimeter (8-inch) diameter Shrike motor for IM testing
- JANNAF SHC Panel Chairman Presented Recommendations to DDESB and Tri-service Hazard Classifiers Regarding Possible Revisions to TB 700-2
  - SHC Panel members recommended eliminating the zero cards requirement for all the gap tests in favor of a shock input of 70Kbars
  - Panel members are in favor of efforts to develop, test and model sub-scale analog rocket motors for bonfire testing

Meeting & Workshop Efforts (Cont)

- Army hazard classifier
  - Uncertain if the propulsion community could adequately determine threshold between HD 1.1 and 1.3 for large rocket motors
  - Favored keeping zero card requirement
- The Navy hazard classifier
  - Endorsed 70 Kbar shock input for the three gap tests with additional testing to determine critical diameter.
  - Supported JANNAF workshop efforts to develop, test and validate subscale bonfire testing for hazard classification
- Air Force hazard classifier
  - Favored keeping zero card requirement
  - Undecided as to what motor diameter is large enough to disregard critical diameter
- DDESB members advocated further testing/analysis for:
  - Shock sensitivity and critical diameter testing
  - Subscale bonfire test protocol for large rocket motors

Meeting & Workshop Efforts (Cont)

- Nov 2000, JANNAF PSHS
  - Workshop to discuss the current status of JANNAF efforts to develop and demonstrate alternate test protocols
    - Shock sensitivity gap and critical diameter tests
    - Sub-scale bonfire test articles and methods

Recent Proposed Testing Efforts

- **Boggs, Graham and Miller "New Shock Sensitivity Test Proposed for Hazard Classification"**
  - **Shock sensitivity testing and modeling to address sample dimensions & attenuation**
    - **Propellant ignition & growth reactive flow models can be used to reproduce observed gap tests for 1.3 as well as 1.1 propellants**
    - **The model can be a viable tool in designing alternative gap test configurations or any other 2-D shock ignition and reaction experiment representing propellant hazard events**
    - **This work indicates that 90% solid loading of a typical AP/Al , binder propellant may be borderline in passing the zero cards SLSGT**
    - **Use of a shorter length donor and a longer length acceptor with PVC confinement may be more realistic for determining the shock sensitivity of propellants**
    - **Nitramine containing AP/Al/binder propellants will never pass the zero cards SLSGT**

Recent Proposed Testing Efforts (Cont)

- Claude Merrill's proposed sub-scale hazard classification program using external fire tests
  - 12-inch analog motor tested with two propellants
    - Zero card (NOL)
    - Multi card (NOL)
  - Analog motor correlated with two full-scale motors
    - 30-inch
    - 60-inch

Summary/conclusions

- UN Test Series 6 Addresses Storage and Transportation Hazards to Distinguish Between Various Class 1 Hazard Divisions
  - Internal ignition, external heating, shock sensitivity
- Series 6 Is Impractical for Large Solid Rocket Motors
  - Alternate tests are a necessity
- Current Alternate Testing Protocol Inconsistent With UN Test Series 6
  - No internal ignition, external heating tests
  - Order(s) of magnitude higher shock input
  - Likely to get very different answer than nominal UN Test Series 6

Summary/conclusions (Cont)

- As a Result of DoD Hazard Classification Changes
  - Many solid rocket propellants & motors will have IHC of 1.3 and a final hazard classification of 1.1
  - Many class 1.3 motors now in production would be reclassified as 1.1 if fielded into a new DoD system
- Past Workshops Tried to Unite Solid Rocket Community and Develop a Standard Protocol for Incorporation Into TB 700-2
  - SHC panel recommendations submitted to DDESB and tri-service hazard classifiers
    - Eliminate the zero cards requirement for all the gap tests in favor of a shock input of 70Kbars
    - Efforts to develop, test and model sub-scale analog rocket motors for bonfire testing should be supported

Summary/conclusions (Cont)

- **Future Workshops Will Focus on Current Status of JANNAF Efforts to Develop and Demonstrate Alternate Test Protocols**
  - **Shock sensitivity gap and critical diameter tests**
  - **Sub-scale bonfire test articles and methods**

Thiokol Propulsion

ALCOA

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